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CHEMICAL RESEARCH DEPARTMENT

ANALYTICAL SERVICES SECTION

1984 ANNUAL REPORT

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To Mr. F. J. Kee
Director of Research

Analytical Services Section - 1984 Review

M. R. Booth

The Analytical Services Section carried out 2488 jobs during 1984, representing the analysis of 17866 samples. Notable events during the year included on-site support of the decontamination of two reactors at Pickering, studies of the efficiency of emission monitoring and control equipment at Bruce, development of procedures for the separation of the isotopes of hydrogen, and the implementation of the capability for the analysis of trace amounts of herbicides in soils. Improved x-ray diffraction capability, new gas chromatographs, and a new low level gamma detector represent the new equipment added to the lab during the year.

This review is intended to provide clients and potential clients of the Analytical Services laboratory with information on the capabilities of the laboratory -especially new capabilities - and examples of the type of work that can be carried out by the lab. Since new capabilities are added in response to client needs, this description is illustrative rather than complete. Discussions with the chemists in the section will provide more detailed information about the feasibility of meeting needs not discussed in this review. The Analytical Services Section provides a wide range of support services and facilities for the Chemical Research Department, other departments in Research Division, and directly for other divisions of Ontario Hydro. The section is committed to the provision of economical, quality analytical chemistry services to the corporation.

By the end of the year, Analytical services handled 2488 jobs and analyzed 17866 samples. The number of jobs and samples was lower than in 1983 (2803 jobs and 20893 samples) but this reflected a change in emphasis rather than a reduction in work volume. The elimination of the large volume totally routine aerosol analysis project associated with acid precipitation studies contributed to the reduction in samples analyzed. The emphasis shifted to increasingly non-routine work of increased complexity. This is reflected in the increased average cost per analysis from $47 in 1983 to $74 in 1984. The number of non-routine jobs requiring direct project control by a chemist almost doubled from 68 in 1983 to 123 in 1984.

A high proportion of urgent requests throughout the year led to problems in meeting the desired turnaround time for routine work. The Section Objective of a two-week turnaround time for routine jobs was met only 40% of the time, compared with 58% in 1983. The average turnaround time per job increased from 20 to 27 days.

1.0 Analytical Services Equipment and Facilities

1.1 Inorganic and Environmental Analysis:

The laboratory has comprehensive classical and conventional chemical analysis capabilities. Sample preparation is an important stage in most of the analyses which are performed. In addition to conventional acid dissolution or fusion techniques a low temperature plasma asher has been used for the preparation of biological samples for trace metal analysis as well as for the surface treatment of polymers used by the Organic Research Section in work related to solid scintillants. Conventional instrumentation such as spectrophotometers, spectrofluorometers, pH meters, automatic titrators and turbidimeters have been widely used in the analysis of environmental samples (eg water hardness, trace oil in water) as well as in support of other projects such as boiler cleaning (determination of residual hydrogen peroxide and iron II / iron III ratios).

An optical emission spectrograph with photographic detection has been widely used for the qualitative (DC arc excitation) and quantitative (AC spark excitation) analysis of metal alloys. The main uses have been the certification of construction materials and for failure analysis. The use of this facility increased significantly during 1984 after a temporary decline for a couple of years.

An EDAX energy-dispersive x-ray fluorescence spectrometer is used for the rapid analysis of a wide range of solid materials. This instrument has proven invaluable for the rapid screening of unknown materials prior to more detailed analysis by other techniques. Many small problems are rapidly and cheaply resolved by the semi-quantitative analysis provided by this facility. A

major application was the examination of CANdecon cruds during 1984. The possibilities for quantitative analysis are limited by the lack of computerized interelement correction capabilities. Unfortunately, the instrument continued to be plagued by maintenance problems in 1984.

Atomic absorption spectroscopy has been the workhorse of the section for the analysis of metals in solution. The four instruments of the section (including one in the Radioactive Materials Laboratory) have been in almost continuous use in the routine analysis of waters (environmental monitoring, analysis prior discharge), alloys (especially when high precision is required) and cements. The instruments include an Instrumentation Laboratory model 751, used for flame work, and an Instrumentation Laboratory Model 951, used with a graphite furnace atomizer. These are dual channel (dual spectrometer) instruments. Special projects have included the following:

1. Determination of trace metals in monels to help resolve a problem with a cooler at Pickering NGS.

2. Analysis of contaminants in mercury from relays used in nuclear stations.

3. Analysis of cruds collected during the decontaminations at Pickering NGS.

4. Verification of methods used for monitoring the progress of CANdecon

Two ion chromatographs provide for the routine analysis of anions and cations in solution. An automated Dionex Model 12 carried out the bulk of the work in the laboratory, while an older Dionex Model 10 has been modified for analysis of radioactive samples in the RML, and has been used on-site at Pickering during CANdecon. There has been a trend away from large environmental survey work on these instruments, with more work coming from operating fossil fuel fired and nuclear generating stations. Significant contributions were made in the determination of ultra-low levels of organic acids in boiler water. Sulfur containing anions (thiosulfate and polythionates) were determined for Nuclear Generation Division. Other applications of ion chromatography included the determination of anions in sludge from boilers, amines in charcoal, and carbon dioxide in moderator water. An electrochemical detector has been purchased for the instrument to permit the sensitive analysis of non-ionic easily oxidizable species such as sulphide, cyanide, polythionates, amines and morpholine, which are now analyzed by less convenient methods.

The laboratory is equipped with a variety of continuous flow analyzers. Due to changing demands, these have been gradually converted from use for large scale environmental surveys to a

variety of tests previously done by manual methods. Although analysis costs are only slightly reduced unless large sample batches are received, precision is significantly improved compared to manual methods. A variety of colorimetric tests are run, including phosphate, silica, boron and cyanide in waters, In addition, one unit has been set up for use with a dedicated older atomic absorption spectrometer for the analysis of arsenic, antimony and selenium by hydride generation, and mercury by the cold vapour method.

An x-ray diffractometer with a large powder camera and a wide range goniometer is available for phase identification. A new power supply was added to the instrument in 1984 to replace the unserviceable original power supply. Since the new power supply was not stable enough for wavelength dispersive x-ray fluorescence studies, the relatively unused XRF goniometer was adapted to XRD service, resulting in a more precise and reliable instrument. (Coincidentally, the wavelength dispersive XRF capability was lost.) The instrument was applied to the analysis of many deposits found during the routine maintenance of the Bruce Heavy Water Plant, Pickering boiler tube sludge pile deposits, oxide corrosion deposits, and deposits collected during the decontamination of the reactors at Pickering. In addition, an updated x-ray powder diffraction file has been added to the laboratory.

Two Leco Induction Furnaces are applied to the determination of Sulphur Hydrogen and Carbon in steels, flyashes, and coals. These instruments again saw very heavy use during 1984, and have been the object of considerable maintenance effort including the acquisition of a new titrator module for sulfur measurements. Of note is the application of this technique for the micro analysis of carbon and hydrogen in organic materials, a unique application of this technology.

The capability of the laboratory for the determination of gases in metals continues to be weak. This is a problem in view of the considerable interest in studies of hydrogen in zirconium metal and zirconium alloys. The existing Leco^{tm} system degasses the metal in an induction furnace under vacuum, and measures the hydrogen by determining the amount which diffuses through a heated palladium thimble. A new high vacuum system has been constructed, and will be applied to gas in metal analysis. Since a gas chromatography finish is planned, greater reliability should result. In addition, it will be possible to analyze for other gases in the metal.

Plans have been completed for the reconstruction of the clean room and reconstruction is underway. An improved air handling and filtration system is expected to reduce the particle count to a level suitable for preparing particle free water for use in

boiler water research studies. This room will meet US Federal Standard Class 500 specifications for clean rooms.

1.2 Organic Analysis:

Organic analyses are carried out using a wide range of chromatographic and spectrometric equipment. Instruments include six conventional gas chromatographs equipped with a variety of detectors.

Much of the work carried out during the year was associated with or impacted upon by the decontamination of units 1 and 2 at Pickering NGS A. The Analytical Services Section provided on-site analytical chemistry services during decontaminations which occurred during January, April and May, as well as at NPD during a December 1983. This required development of suitable methods for rapid analysis of oxalic and citric acid, ethylenediamine tetraacetic acid, and Rodine 31A inhibitor, as well as the analysis of cations in the solutions. These techniques were then applied by teams of analysts to follow the changes in the reagent concentrations in the heat transport system during the entire decontamination process. The development work, on-site work, and the following post-decontamination analytical chemistry were major unplanned additions to the work of the lab.

A Finnigan Model 4000 gas chromatograph/mass spectrometer with a comprehensive data management system is available for specialized studies requiring the identification of totally unknown components in gas, liquid or solid samples, isotopic analysis of volatile gases and vapour mixtures, and routine quantification of analytes in complex matrices. The mass spectrometer is accessible through the gas chromatographic interface, through a solid-probe sampler, or through a direct gas inlet and is capable of both positive and negative ion detection in the electron impact and chemical ionization modes. It is also equipped with a liquid chromatographic interface. The instrument has been used for the determination of trace organic components in boiler water, determination of decomposition products in sulfur hexafluoride gas, the measurement of $^{14}CO_2$ in annulus and moderator gases, the measurement of polynuclear hydrocarbons in flyash and water, identification of odours in the workplace, development of inhibitor analytical techniques for Candecon, quality control of PVC Water Stops, and conveyor belt degradation studies. Health and Safety Division and operating plants continued to submit samples of phosphate ester hydraulic fluids used in nuclear plants. Thermal Generation Division asked for determination of trace levels of amines in boiler waters to support a study of various boiler water pH control agents.

A conventional dispersive infrared spectrometer is available for qualitative and quantitative analyses. This instrument is plan-

ned to be supplemented by a modern Fourier Transform infrared spectrometer in 1985 to enhance the ability to study organic and polymeric materials in the laboratory.

The Hydraulic Generation and Transmission Division routinely sample the oil in transformers for dissolved gas analysis to identify potential problems before the transformer fails in service. In 1984 Analytical Services analyzed approximately 2000 samples of transformer oils as part of this program. The analytical system includes a vacuum system which is used to extract the gases from the oil, and to compress an aliquot of the extracted gas into the sampling loop of the Varian Model 6000 Gas Chromatograph. The gas chromatograph is equipped with Poropak and molecular sieve columns, a thermal conductivity detector and a flame ionization detector (preceded by a hydrogenation stage to convert carbon oxides to methane) for detection and measurement of methane, ethane, ethylene, acetylene, carbon monoxide, carbon dioxide, hydrogen, nitrogen, and oxygen. The data is analyzed using a Vista 402 data station.

The analysis system is flexible, and has been applied to the preparation and measurement of gas samples of other types, including the analysis of gases contained in moderator cover gas and annulus gases at nuclear generating stations.

Ontario Hydro continues to be interested in the PCB analysis in various oil filled devices on the system. A rapid, inexpensive gas chromatographic screening process has been set up in the lab to provide information required. The chromatography is carried out on a Hewlett-Packard 5840 Gas Chromatograph equipped with a 30 m capillary column and an electron capture detector, which is very sensitive for halogenated hydrocarbons. The chromatography is temperature programmed, and resolution obtained by the capillary chromatography permits more specific PCB analysis. The instrument equipped with an automatic sampler, which permits the unattended analysis of 100 samples and standards. Quantitative analyses are carried out when specifically requested, or when the screening test indicates the presence of PCB at about 40 PPM or greater.

The capability for the analysis of PCB's in oil has attracted the interest of other users of electrical devices which might be contaminated with PCB, including a number of Municipal Utilities in Ontario. The equipment was also used to support the research on the destruction of PCB using the liquid sodium process which was developed by the Organic Research Section.

A sample preparation, extraction and analysis technique was developed for the analysis of trace levels of herbicides in soils, water, and vegetation using an esterification/gas chromatographic technique. A newly acquired Varian 6000 gas chromatograph

chemistry capability for the speciation of hydrogen isotopes in annulus gases.

1.3 Radioactive Materials:

Facilities for handling and counting radioactive materials are available in a medium-level and an environmental level radioactive materials laboratories.

A full range of nuclear counting equipment is available for sample analysis. Complex gamma spectroscopy is carried out with a computer based Ortec Model 7052 system equipped with two high-resolution detectors, while simple gamma analysis is performed using a Canberra Series-30 multichannel analyzer and sodium iodide detectors. During 1984 an Ortec Model 572 dual channel alpha spectrometer was interfaced to the 7052 data acquisition system for analysis of alpha emitting radionuclides, while a Nuclear Measurements Corporation Model PC-5 proportional flow counter is used for both gross alpha and gross beta activity counting. A Searle Mk III liquid scintillation counter is also used for analysis of beta emitting radioisotopes.

The environmental level counting facility is equipped for low background alpha, beta, and gamma activity counting. During 1984 a new intrinsic germanium detector was ordered and an existing Canberra Scorpio gamma spectrometer was refurbished to augment the gamma counting capability presently available through a Canberra Series -80 spectrometry system. This second system is expected to be operational in early 1985. A new Model PC-5 proportional flow counter was also acquired in 1984 to support such analyses as strontium-90 and gross alpha and gross beta measurements in low activity samples. A Packard Model B306 Tri-Carb sample oxidizer is available for automatic sample preparation for the analysis of tritium and carbon-14 in solid and biological materials. Such samples are then counted on a Packard Model 300 CD micro-processor based liquid scintillation counter. The scintillation counter has also been used for counting the activities of various other radionuclides in biological materials, such as Ca-45 in fish tissue.

A rapid method for the determination of radium in flyash leachates and ground waters using an especially prepared barium sulphate suspension to carry down radium and its subsequent determination by alpha spectrometry is now in regular use in the laboratory. The detection limit is 0.2 pCi/L.

Access to experimental reactors at University of Toronto, and at McMaster University has permitted staff to gain experience in instrumental neutron activation analysis, and to apply this technique to the detection of trace elements in a variety of liquid and solid materials.

equipped with an electron capture detector and an autosampler was used for the detection of PPB levels of herbicides in samples submitted by Biological Research and by Transmission Environment.

A Varian 6000 Gas Chromatograph equipped with a nitrogen/phosphorus sensitive detector was used for the analysis of a wide range of materials. Of particular note was the application to the analysis of EDTA in boiler cleaning solutions, both at Pickering NGS during the decontaminations, and in support of the extensive research studies carried out by the Inorganic and Environmental Section in support of the characterization of the decontamination. The instrument was applied to the analysis of triethylenediamine in charcoal for the qualification of the material for use in emission control systems at nuclear power plants. Morpholine and other amines were measured at the parts per billion level in boiler water for Thermal Generation Division. Fyrquel (triarylphosphate) has been routinely analyzed in samples from generating stations.

A HP 5710 gas chromatograph equipped with column switching valves and an electron capture detector was set up for the trace analysis of sulfur hexafluoride in air for the Atmospheric Sciences Section. The same instrument was used for the determination of methyl iodide capture in charcoal beds in Bruce NGS stacks to determine the effectiveness of the filters for the collection of radio-iodine.

In support of a CFFTP contract developing waste treatment systems to recover tritium from waste gaseous and liquid streams associated with the future operation of fusion reactors the Analytical Services Section developed the basic information for the chromatographic separation of hydrogen isotopes. A bench scale chromatographic system was set up and the complete separation of all hydrogen isotopes (ortho and para hydrogen, deuterium, tritium -including HD, HT, and DT) has been demonstrated. The system was built around a modified commercial gas chromatograph. The hydrogen isotopes were separated on Molecular Sieve columns operated at temperatures of from -130°C to -160° and the gaseous components are detected with thermal conductivity and beta-sensitive detectors. Critical to the success of the project was the development of two pieces of hardware; the beta-sensitive detector and an inexpensive column temperature control device. The basic operating principles of the beta detector were similar to a flow proportional detector, but with significant changes to the detector cell and the counting electronics. The bench scale system was scaled up by a factor of ten and the capacity of the chromatographic columns was characterized. Estimates of the tritium gas processing rate as a function of the desired enrichment of the product gas have been made and the data was used to estimate the degree of scale-up required for both waste recovery and fuel cleanup. This work has formed not only the basis of planned isotope separation facilities, but added a new analytical

particulate matter emissions and losses of these species in the sample delivery lines due to deposition and adsorption. Equipment and procedures were developed for injecting known quantities of methyl iodide, elemental iodine, and particulate matter (sodium fluorescein) into the stacks and each species was then sampled at strategic locations in the monitoring systems. The results from extensive testing on the Bruce NGS A Unit 4 contaminated stack showed the existing probe and sample delivery line to be supplying a representative sample of the stack emissions to the monitor, even though the probe was not designed for isokinetic sampling, and was located in an area of the stack where a highly skewed velocity profile was found to exist. However, problems due to leakage of ambient air into the monitor itself were identified during the test program. Subsequent testing of the Bruce NGS A Unit 1 non-contaminated stack showed the probe design in that stack to be incapable of supplying a representative sample of either the particulate matter or gaseous iodine emissions. A new probe is being designed based on these results. Results from tests on the Bruce NGS B Unit 5 stacks are still being assessed, but the preliminary indications are that a low bias of 10 to 30% occurs in the Unit 5 Non-contaminated stack monitor, while the Unit 5 Contaminated stack monitor is being supplied with representative samples of stack emissions. This work is continuing in 1985.

2.0 Quality Assurance Program

Analytical Chemistry laboratories produce large quantities of numbers which are used by clients as the basis of conclusions or actions. Management of an analytical chemistry laboratory requires that we address the questions:

What is the quality of our data?
Do the users trust our data?
Would regulatory agencies use our data?

These questions can only be addressed through a formal quality assurance program. The past year marked significant progress on the path toward obtaining documented, justified confidence in the data which were produced.

There are two separate functions in the QA process. The first is the control function. This can be a formal, externally applied system, or can be expert based. The formal control process relies on documented and standardized procedures, and applies mostly to routine analyses, such as the PCB or transformer gas analyses. The expert based, or "artisan" approach applies primarily to non-routine or research type of activities. In this approach, the expert takes appropriate steps to ensure the quality of the data, and the laboratory relies on the expert.

Nuclear Generation Division have been submitting nuclear fuel rod samples to the laboratory for analysis for about ten years. The analytical requirements were reviewed again this year with CNS, and the procedure was considerably simplified. The analysis is directed now to the determination of all sources of hydrogen in the fuel rod (hydrocarbons, hydrogen, and water) rather than being a comprehensive chemical analysis. The equipment for the handling and analysis of the fuel rods has been completely reconstructed to increase the reliability and sensitivity of the system, while decreasing the labour required in the analysis.

1.4 Surface Analysis Laboratory

The Surface Analysis Laboratory is centred around a JEOL JAMP-10 Scanning Auger Microprobe, equipped with an argon-ion gun for sputter depth profiling and an energy dispersive x-ray fluorescence analyzer. Unfortunately, the x-ray probe continues to adversely affect the ultra-high vacuum which is essential for Auger electron analysis, and has also caused an unacceptable loss of filament life in the instrument. The probe is being returned to the vendor for repair.

Much of 1984 was spent in developing and perfecting techniques for the depth profiling of active and inactive species in oxide scales on steel components from Hydro's nuclear reactors in support of decontamination research. Ion-sputtering proved to be ideal for the relatively thin (less than 10 microns) scales on samples of stainless steels. However, simple abrasion with emery paper was more suitable for the thick oxide scales (up to 100 microns) found on carbon steel surfaces.

A number of improvements to the surface analysis capabilities are now in progress. A mechanical abrasion device, based on the technique of ball cratering, has been ordered and is expected to be available before March. In addition, a quadrupole mass spectrometer based residual gas analyzer is being acquired, which will provide analytical data on the surface adsorbed species such as water or hydrocarbons.

1.5 Stack Testing Services

Expertise and equipment are available for the sampling and measurement of particulate and gaseous stack effluents in accordance with procedures specified by the Federal and Ontario Source Testing Codes. In addition, custom design and construction of sampling and monitoring systems can be provided.

A major project has been in progress during 1984 to assess the performance of the sampling and delivery systems on existing stack monitors at Bruce NGS A and B. Two potential problems were investigated; non-representative sampling of the radioiodine and

The formal assessment process is the demonstration that control activities are functioning as they should. This process also relies heavily on documentation, including periodic formal review of data from control standards, spike/recovery tests, and calibration tests; the carrying out of method audits, including analysis of blind samples; participation in interlaboratory tests, and the periodic formal summary of these activities.

The following quality assurance activities have taken place to ensure that the quality assurance program is followed uniformly in the entire laboratory, and to ensure that procedures defined were followed by all staff.

1. An in-house computer program has been in place to log in all samples and to keep track of all uncompleted work. Samples are assigned to one of three lead technicians or to chemists who are responsible for sample custody. A system of alpha-numeric identification identifies each sample with respect to custody information. Sample registration is tied directly to report generation. As a consequence, no report can be generated unless samples have been registered.

2. A chemist has been assigned the specific responsibility for problem definition. For complex problems, or specialized requirements, other chemists are involved. Special requirements of the users are documented and passed on to the analysts.

3. The process of documenting methods in use has been initiated, and many procedures have been documented. The preparation of a laboratory manual has been initiated. Progress in this area has meant use of more uniform methodology throughout the laboratory.

4. Logs of instrument performance and maintenance including information on time of use, problems, routine and non-routine maintenance and calibration data are maintained.

5. Response information from standard samples in recorded during many analyses and the information is recorded and trended. Significant changes in trends are flagged.

6. Most high volume analyses are controlled by Shewhart type control charts.

7. A protocol exists for the verification of data produced from some analyses. These include tests such as mass balance, charge balance, and comparisions with historical data.

8. Internal audits are carried out where the method is examined in detail. Quality assurance samples supplied by

the USEPA or prepared internally are sent through the laboratory periodically as blinds.

9. Participation in interlaboratory studies is a high profile activity within the laboratory. This laboratory participates in the following round robin tests:

US Environmental Protection Agency

RTP-Air pollution filters for sulfate, nitrate, lead

Cincinnati-wastewater, water supply sample for major anions, cations, trace elements, herbicides, and PCB.

Las Vegas-radioisotopes in air filters and water at low concentration.

US Geological Survey

Water and precipitation samples for major anions, cations, and trace elements

Environment Canada

Groundwater and precipitation samples for major anions, cations, and trace elements

Other special studies-eg urban dust

International Joint Commission

Lakewater for trace contaminants

Canadian Standards Association

cements

Internal Round Robins

Nuclear station labs

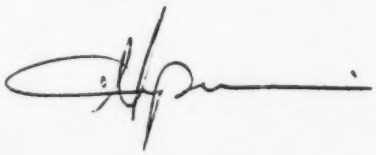
coals

10. Each analytical report leaving the laboratory is assessed on an overall basis. Using informal guidelines, the reports are assessed at two different supervisory levels before being released.

3.0 Summary

The Analytical Services Section has continued to supply needed support services for the Chemical Research Department, other Departments in the Division and to other Divisions. The capabilities of the section have increased, especially in the area of Organic Chemical analysis. The large project associated with the decontamination of Pickering was accommodated, though significant disruption to other priorities resulted. The variety of work carried out and the accommodation of changing work requirements are a tribute to the flexibility and competence of the technical and professional staff of the section.

Approved by:



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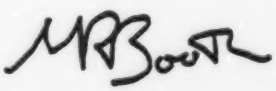

M.R. Booth
Supervising Chemist
Analytical Services Section

CATEGORY A REPORTS

83-527-K	Particulate Emission from the Unit 4 Contaminated Stack at BNGS-A (K.E. Curtis)	837.213x 837.29	Jan 20/84
84-8-K	Determination of Elemental and Oxidized Tritium in Growth Chamber Air (K.E. Curtis)	837.201	Feb 27/84
84-77-K	The Analysis of Pickering NGS-A Unit 2 - End Fitting Lines (F.R. Greening)	836.3332	Mar 14/84
84-262-K	The Analysis of Oxide Scales Formed on Feeder Pipes from Pickering NGS-A Units 1 and 2 (F.R. Greening)	836.3332	Aug 13/84
84-261-K	Procedures for the Injection of Non-Radioactive Iodine and Particulate Matter into the Bruce NGS-A Unit-4 (K.E. Curtis)	837.29	Aug 29/84
84-273-K	Sampling of Injection Iodine in the Unit 4 Contaminated Stack at Bruce NGS-A (K.E. Curtis)	837.29	Aug 20/84
84-274-K	Sampling of Injected Particulate Matter in the Unit 4 Contaminated Stack at Bruce NGS-A (K.E. Curtis)	837.29	Aug 22/84
84-359-K	Radionuclide Depth-Profiling (F.R. Greening)	830.6148	Nov 8/84
84-308-K	Cyanide in Fly Ash Leachates (O. Herrmann)	837.3	Sept 28/84
84-328-K	Strontium-90 Activity in Pickering NGS Heat Transport Water (K.E. Curtis)	836.3332	Nov 8/84
84-420-H	Determination of Precipitated Oxalate (O. Herrmann)	836.29	Dec 21/84

CATEGORY B REPORTS

C84-14-K	Measurement of Chloride Emissions from the Fire Test Laboratory (K.E. Curtis)	832.1	Jan 27/84
C84-22-K	Candecon Support (O. Herrmann)	836.29	Feb 22/84
C84-59-H	The Analysis of Fly Ash for Poly-Chorinated Debenzo Dioxins and Furans (R.E. Massey)	837.71	June 27/84
C84-54-H	Measurement of the Dioxin Content (O. Herrmann)	837.3	Sept 28/84
C84-105-K	Report on the 27th Oak Ridge National Laboratory/US Dept of Energy Conference on Analytical Chemistry in Energy Technology at Knoxville, Tennessee October 2-4, 1984 (S.H. Mehdi)	830.5	Nov 229/84